ANTENNA AND METHOD FOR MANUFACTURING THE SAME

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an antenna for small size electronic equipment.

Description of Related Art

As earlier developed electronic equipment that utilizes electric wave information by receiving the electric wave, there is an electronic wristwatch that performs time adjustment automatically by receiving electronic wave of the standard time.

As an antenna provided in such an electronic wristwatch to receive the electric wave, it has been known to form an antenna by winding a coil on a core material which comprises a magnetic material with a good reception sensitivity such as ferrite, amorphous or the like as disclosed in Japanese Patent Laid-Open Publication No. 2001-337181.

It has also been known that the reception sensitivity of an antenna is affected by the shape of the core material and is improved when both ends of the core material are enlarged. For example, the both ends of the core material

can be easily enlarged by a molding that has certain degree of freedom in designing the shape, so that the reception sensitivity can be improved.

However, for example, when the core material is formed by laminating a plurality of thin plates made of the magnetic material or binding a plurality of wire rods made of the magnetic material, the degree of freedom in designing the shape is limited. Thus, a thickness of the core material is constant and the optimization of the shape of the core material to the reception sensitivity has not been accomplished.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an antenna that has an improved reception sensitivity by using a core material which is made of magnetic material.

In order to solve the above-described problem, the antenna according to the invention comprises:

a core material which is formed by laminating a plurality of thin plates made of a magnetic material, both end portions of the core material being widened in a thickness direction; and

a coil which is wound around the core material.

According to the invention, the core material of the antenna is formed by laminating a plurality of the thin plates made of the magnetic material, and the both ends of the core material are widened in the thickness direction. Thus, the thickness of the both ends of the core material becomes larger than that of a central portion, so that the reception sensitivity of the electric wave can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of an antenna according to the present invention;

FIG. 2 is a rear view of the antenna in FIG. 1;

FIG. 3 is a section view taken along the line III-III of FIG. 1;

FIG. 4A is a plan view showing a thin plate that forms a core material of the antenna of the present invention, and FIG. 4B is a side view of the thin plate in FIG. 4A;

FIG. 5A is a side view showing a core material case which is used for the antenna of the present invention, FIG. 5B is a transverse side view of FIG. 5B seen from the direction of the arrow b, and FIG. 5C is a transverse side view of FIG. 5A seen from the direction of the arrow c;

FIG. 6A is a top view showing an upper case forming

the core material case which is used for the antenna of the present invention, FIG. 6B is a side view of the upper case in FIG. 6A, FIG. 6C is a bottom view of the upper case in FIG. 6A, and FIG. 6D is a section view taken along the line d-d of FIG. 6A;

FIG. 7A is a top view showing a lower case forming the core material case which is used for the antenna of the present invention, FIG. 7B is a side view of the lower case in FIG. 7A, and FIG. 7C is a bottom view of the lower case in FIG. 7A;

FIG. 8 is a front view showing an antenna body of the antenna according to the present invention;

FIG. 9 is a side view showing the antenna body of the antenna according to the present invention;

FIG. 10 is an enlarged section view showing the main portion of an electronic wristwatch in which the antenna of the present invention is contained;

FIG. 11 is a view showing a frame format of variation 1 of the antenna according to the present invention;

FIG. 12 is a view showing a frame format of variation 2 of the antenna according to the present invention;

FIG. 13 is a view showing a frame format of variation 3 of the antenna according to the present invention;

FIG. 14 is a view showing a frame format of variation 3 of the antenna according to the present invention; and

FIG. 15 is a view showing a frame format of variation

4 of the antenna according to the present invention.

PREFERRED EMBODIMENT OF THE INVENTION

Hereinafter, the preferred embodiments of the present invention will be described in detail by reference to the attached drawings.

FIG. 1 is a front view of an antenna according to the present invention, FIG. 2 is a rear view of the antenna, and FIG. 3 is a section view taken along the line III-III of FIG. 1.

As shown in FIGS. 1-3, an antenna 100 comprises an antenna body 20, a connection member 40 for electrically connecting the antenna body 20 with a breadboard (not shown) of electronic equipment and the like.

The antenna body 20 comprises a core material 11 which is formed by laminating a plurality of thin plates 1 comprising a magnetic material, a spacer 2 which is sandwiched between the predetermined thin plates at both end portions of the core material 11 in a longer direction, a core material case 3 for containing the core material 11 therein, a coil 4 which is wound around the core material case 3 or the like.

The thin plate 1, as shown in FIG. 4, comprises a core central portion 1a and a core end portion 1b that is

formed at both ends of the core central portion 1a in longer direction. The thin plate 1 is an approximately H-shaped thin plate member from the plan view and is made of amorphous which is a magnetic material. A width of the thin plate 1 at the core end portion 1b in shorter direction is wider than a width of that at the core central portion 1a. Each core end portion 1b has a shape comprising an inclined portion which is formed by cutting diagonally one corner of an approximately rectangle.

An example of a specific dimension of the thin plate 1 is as follows. The thickness is 0.016mm, the length in the longer direction is 15.6mm, the length of the core central portion 1a in the longer direction is 11.2mm, the width of the core central portion 1a in the shorter direction is 1.4mm, and the width of the core end portion 1b is 4.7mm.

A plurality of the above-described thin plates 1 is laminated to form the core material 11.

The spacer 2 is a wedge shaped member, which is placed between predetermined thin plates 1 at both end portions thereof and sandwiched when the thin plate 1 is laminated. Thus, the core end portions 1b that are the both end portions of the thin plate 1 are widened in the thickness direction.

The core material case 3 that contains the core material 11 therein comprises the upper case 3a and the lower case 3b as shown in FIGS. 5-7.

The core material case 3 forms a container 30 which

is a space formed between the upper case 3a and the lower case 3b when they are incorporated, that is, between the under surface of the upper case 3a and the top surface of the lower case 3b. The container 30 contains the core material 11.

The core material case 3 comprises a central portion 5 which covers a portion corresponding to the core central portion 1a of the thin plate 1 forming the core material 11, end portions 6a and 6b each of which is provided at each end of the central portion 5 and cover a portion corresponding to the core end portions 1b of the thin plate 1 forming the core material 11. The space of the container 30 in the end portions 6a, 6b is gradually widened toward a head of the each end portion 6a, 6b corresponding to the shape of the core end portions 1b of the thin plate 1 and the shape of the core material 11 corresponding to the core end portions 1b.

A positioning pin 7a for carrying out positioning of the connection member 40 and two positioning protrusions 7b are formed on a portion corresponding to the one end portion 6a on a top surface of the upper case 3a. An upper flange 8 is formed on the top surface of a portion corresponding to the other end portion 6b of the upper case 3a. The upper flange 8 protrudes to the height same as the top surface of the one end portion 6a.

A lower flange 9 is formed at an under surface of each end portion 6a, 6b. Each of the lower flanges 9 protrudes the same height.

An example of a specific dimension of the core

material case 3 is shown in FIGS. 5-6. In the figures, the length of the core material case 3 in the longer direction is 16.0mm, the length of the central portion 5 in the longer direction is 10.4mm, the width of the central portion 5 in the shorter direction is 2.2mm, the width of the end portions 6a, 6b is 5.4mm, the thickness of the central portion 5 is 1.6mm, and the length from the under surface of the lower flange 9 to the top surface of the upper flange 8 (from the under surface of the lower flange 9 to the top surface of the end portion 6a) is 4.8mm.

The coil 4, for example, is a copper wire and is indirectly wound around the core material 11 through the core material case 3. As shown in FIGS. 8 and 9, the coil 4 is wound around the central portion 5 of the core material case 3 in approximately even thickness so as to make side surfaces of the coil 4 and each side surfaces of the end portions 6a, 6b of the core material case 3 approximately be in the same plane. Specially, the coil 4 is wound to make top and under surfaces of the coil 4 and the top surface of the upper flange 8 and the under surface of the lower flange 9 approximately be in the same plane, respectively.

For example, the coil 4 of copper wire having a diameter of 0.1mm is wound around the central portion 5 1195 times (14 layers).

The connection member 40 comprises a flexible substrate, and at one end portion 41 of which is provided with an positioning hole 43 through which the positioning pin 7a formed on the end portion 6a of the core material

case 3 (the upper case 3a) is inserted to carry out positioning of the connection member 40 to the end portion 6a. A positioning groove 44 is provided at an edge portion 41a of the one end portion 41. The positioning groove 44 is engaged with the positioning protrusion 7b which is formed on the end portion 6a of the core material case 3 (the upper case 3a) to limit the rotation of the connection member 40 around the positioning pin 7a. The connection member 40 is positioned at a predetermined position of the antenna body 20 (or the end portion 6a of the core material case 3 (the upper case 3a)) by aligning the positioning pin 7a and the positioning protrusion 7b with the positioning hole 43 and the positioning groove 44, respectively, to be attached.

The other end portion 42 of the connection member 40 is formed so as to be attached to electronic equipment with electrically connectable to a circuit substrate (not shown) thereof.

Two lead wires 45 are provided between the one end portion 41 and the other end portion 42 of the connection member 40. A lead terminal 45a is formed at the one end portion 41 for each lead wire 45. At the lead terminal 45a, each end of the coil 4 of the antenna body 20 protrudes from the rear surface side of the connection member 40 to the front surface side thereof through a through-hole (not shown), and is attached by applying solder 46 in a state of electrically being connected. The lead wire 45 at the other end portion 42 of the connection member 40 is electrically connected to the circuit substrate (not shown)

of the electronic equipment, so that the connection member 40 electrically connects the antenna body 20 and the electronic equipment (not shown).

A method for manufacturing the antenna 100 according to the present invention will be described.

In a first step, a plurality of thin plates 1 is laminated while matching a flat shape thereof. After laminating a predetermined number of thin plates 1, the spacer 2 is placed at the core end portions 1b that are the both ends of the thin plate 1. In this case, a tip of an acute angle side of the spacers 2 with a wedge shape which are placed at both ends of the thin plate 1 should face toward the center from both ends and oppose each other.

Moreover, a plurality of thin plates 1 is laminated thereon. The thin plate 1 is laminated as is described above at the core central portion 1a. However, the core end portion 1b is bent by the spacer 2 which is placed at both ends of the thin plate 1 in the vicinity of the border of the core central portion 1a and the core end portion 1b. Accordingly, the thin plate 1 is laminated while being bent toward the thickness direction of the thin plate 1 so as to be separated from the core end portion 1b which is laminated before the spacer 2 is placed.

Since the spacer 2 is placed between predetermined thin plates 1 when a predetermined number of thin plates 1 are laminated to form the core material 11, the both ends of the core material 11 can be widened toward the thickness direction thereof.

In a second step, the core material 11 which is

formed as described above is sandwiched from the thickness direction of the core material 11 by the upper case 3a and the lower case 3b, and is contained in the container 30 which is formed between the upper case 3a and the lower case 3b.

In a third step, the coil 4 is wound indirectly around the core material 11 through the central portion 5 of the core material case 3 which is formed by combining the upper case 3a and the lower case 3b in approximately even thickness. The coil 4 is wound so as to make the side surfaces of the coil 4 and the each side surfaces of the end portions 6a, 6b of the core material case 3 approximately be in the same plane as shown in FIG. 8, and to make the top and under surfaces of the coil 4 and the top surface of the upper flange 8 and the under surface of the lower flange 9 approximately be in the same plane, respectively, as shown in FIG. 9. Thereby, the antenna body 20 is formed.

The positioning pin 7a and the positioning protrusion 7b of the antenna body 20 side are aligned with the positioning hole 43 and the positioning groove 44 of the connection member 40 side, respectively, so that the connection member 40 is positioned at a predetermined position of the antenna body 20 (or the end portion 6a of the core material case 3 (the upper case 3a)) and attached.

In this way, the antenna 100 is assembled and manufactured.

An embodiment of the above-described antenna will be explained with a comparative example.

The antenna 100 of the present invention shown in FIGS. 1-3 is manufactured. In the antenna 100, the Q-values for each of the electric waves of 40kHz and 60kHz were measured under the condition that the inductance (L) is about 20mH. The result will be shown in table 1.

As a comparative example, an antenna is manufactured. In the antenna, a core material is formed only by laminating the thin plate 1 without using the spacer 2 when assembling the antenna. The Q-values for each of the electric waves of 40kHz and 60kHz were measured under the condition that the inductance (L) is about 20mH. The result will be shown in table 2.

Table 1

No.	40KHz		60KHz	
	L (mH)	Q	L (mH)	Q
1	19.99	98.0	20.57	95.7
2	19.89	98.0	20.50	96.4
3	20.00	92.7	20.60	88.1
4	20.37	96.7	20.97	93.7
5	20.12	96.7	20.22	95.5
6	20.3	98.3	20.92	95.6
7	20.05	99.5	20.64	96.6
8	20.15	99.4	20.77	96.6
9	20.35	91.3	20.97	86.5
10	20.25	99.6	20.87	97.3
AVERAGE	20.15	97.02	20.70	94.20

Table 2

No.	40KHz		60KHZ	
	L (mH)	Q	L (mH)	Q
1	20.91	86.5	21.61	86.3
2	20.55	86.4	21.22	84.0
3	20.66	81.9	21.30	77.3
AVERAGE	20.707	84.93	21.377	81.67

As shown in Table 1, in the antenna 100 comprising the core material 11 which is widened at both ends (core end portions 1b) of the core material (thin plate 1) by the spacer 2 in the thickness direction, the average Q-value for the electric wave of 40kHz is 97.02, and the average Q-value for the electric wave of 60kHz is 94.20. As shown in Table 2, in an antenna for comparison comprising a rod-like core material which is formed only by laminating the thin plate 1 without both ends of the core material being widened, the average Q-value for the electric wave of 40kHz is 84.93, and the average Q-value for the electric wave of 60kHz is 81.67.

Accordingly, since the Q-value of the antenna 100 in the present invention is larger than that of the comparison antenna, it is to be understood that the reception sensitivity of the antenna 100 is better than that of the antenna for comparison. That is, the reception sensitivity of the electric wave is improved by widening the both ends of the core material 11 using the spacer 2.

The core material 11 provided in the antenna 100 is

formed by laminating a plurality of thin plates 11 that is made of amorphous. Further, the both ends of the core material 11 are widened in the thickness direction of the core material 11. Thus, the reception sensitivity of the electric wave can be improved.

Specially, the thin plate 1 used in the embodiment has an approximately H shape from the plan view with the core end portion 1b formed at both ends of the core central portion 1a in the longer direction wider than the width of the core central portion 1a. Thus, the both ends of the core material 11 have a shape larger than the core central portion 1a from the plan view. In the invention, the both ends of the core material 11 are widened in the thickness direction of the core material 11, so that the size of the both ends can be enlarged and the reception sensitivity of the electric wave can be improved more.

FIG. 10 is an enlarged section view showing the main portion of an electronic wristwatch 50 in which the antenna in the present invention is contained. The electronic wristwatch 50 comprises a wristwatch case 51 made of synthetic resin. A watch glass 52 is provided at an upper portion of the wristwatch case 51, and a bezel 53 made of metal is attached on the periphery of the upper portion of the wristwatch case 51. Further, a watch module 54 is contained inside the wristwatch 51 and a back lid made of metal is attached at a lower portion of the wristwatch 51 through a waterproof ring 56.

The watch module 54 comprises at least one of an analogue function and a digital function that are not shown.

The analogue function comprises an analogue movement contained in a housing. An axis of a pointer protrudes upwardly from a dial, and a pointer such as an hour hand, a minute hand or the like is attached on an upper end portion of the axis of the pointer so that the pointer moves above the dial. The digital function comprises a flat type display panel disposed above the housing such as a liquid crystal display panel, EL panel (electroluminescence panel) or the like. The display panel is formed to electrically display information such as the time. The watch module 54 comprises a breadboard (not shown) for driving the analogue movement or the display panel.

A band attaching portion 57 is formed at both sides of the 12 o'clock side and the 6 o'clock side of the wristwatch case 51 (only the 12 o'clock side is shown in FIG. 10), which protrudes diagonally in downward direction. An antenna containing concavity 58 is provided at a side of the wristwatch case 51 at which the band attaching portion 57 at the 12 o'clock side is positioned. The antenna containing concavity 58 which is for containing the antenna 100 is configured so as to be exposed to an outer surface of the wristwatch case 51 and be provided with a communicating hole 59 which is communicated with the inside of the wristwatch case 51. A protection cover 61 for protecting the antenna 100 by covering the antenna 100 is attached on the outer surface of the wristwatch case 51 that faces to the antenna containing concavity 58 by deposition. The protection cover 61 is formed by synthetic resin so as not to shield the electric wave. The antenna

body 20 of the antenna 100 is adhered to the antenna containing concavity 58 and the protection cover 61 by a double-faced adhesive tape 62. The connection member 40 of the antenna 100 is placed into the watch module 54 in the wristwatch case 51 through the communicating hole 59 to be electrically connected to the breadboard (not shown).

The shape of the core material in which both ends of the core material are widened in the thickness direction is not limited to the shape of the above-described core material 11.

For example, as the variation 1 shown in FIG. 11, the core material 11a may have a structure in which both sides of the core material 11a across the spacer 2 are widened to the both sides by the spacer 2 in the thickness direction. In this structure, the open area ratio is increased as compared to the structure in which one side of the core material 11 is widened. Thus, the reception sensitivity is further improved.

For example, as the variation 2 shown in FIG. 12, the core material 11b may have a structure in which the spacer 2a is placed between each thin plate 1 so that each thin plate 1 is separated each other and both ends of the core material 11b is widened in the thickness direction.

For example, as the variation 3 shown in FIG. 13, the spacer 2b may have a shape that is suitable for separating each thin plate 1. Further, for example, as the variation 4 shown in FIG. 14, a plurality of the spacers 2c may be

placed between thin plates 1.

In the shape of the spacer shown in FIG. 13 or 14, bending stress is not regionally concentrated as in the case of using the spacer shown in FIGS. 1-3. Accordingly, the bending stress can be dispersed, and, for example, a crack or the like which is produced by a stress concentration can be prevented.

For example, as the variation 4 shown in FIG. 15, the core material 11c may be formed by binding a plurality of wire rods 10 made of amorphous, and a tip portion 10a of the wire rod 10 may be widened from the center of a bundle in the outer direction at both ends.

In the core material of the antenna in the variation 4, the both ends of the core material 11c which is formed by binding a plurality of wire rods 10 made of amorphous is widened from the center of the bundle. Thus, the diameter of the both ends of the core material 11c is larger than that of the central portion, and the reception sensitivity of the electric wave can be improved. Accordingly, the effect similar to the antenna in FIGS. 1-3 can be obtained.

In the embodiment, the spacer is placed and sandwiched between the thin plates to widen the core material in the thickness direction, however, the present invention is not limited thereto. A space may be formed between thin plates without using the spacer to widen the core material in the thickness direction.

The spacer may be inserted between the predetermined thin plates after forming the core material 11 as well as placing and sandwiching the spacer when laminating the thin plate 1.

For example, a ferrite may be used as a material for the spacer.

The thin plate or the spacer may be fixed by adhering or the like after the lamination thereof.

Further, it is to be understood that the specific detail structure or the like can be changed accordingly.